

## § 90.415

## 40 CFR Ch. I (7–1–10 Edition)

### § 90.415 Raw gaseous sampling procedures.

Fit all heated sampling lines with a heated filter to extract solid particles from the flow of gas required for analysis. The sample line for HC measurement must be heated. The sample line for CO, CO<sub>2</sub> and NO<sub>x</sub> analysis may be heated or unheated.

### § 90.416 Intake air flow measurement specifications.

(a) If used, the engine intake air flow measurement method used must have a range large enough to accurately measure the air flow over the engine operating range during the test. Overall measurement accuracy must be two percent of full-scale value of the measurement device for all modes except the idle mode. For the idle mode, the measurement accuracy must be ±five percent or less of the full-scale value. The Administrator must be advised of the method used prior to testing.

(b) When an engine system incorporates devices that affect the air flow measurement (such as air bleeds, air injection, pulsed air, and so forth) resulting in understated exhaust emission results, make corrections to the exhaust emission results to account for such effects.

### § 90.417 Fuel flow measurement specifications.

(a) Fuel flow measurement is required only for raw testing. Fuel flow is allowed for dilute testing.

(b) The fuel flow measurement instrument must have a minimum accuracy of one percent of full-scale flow

rate for each measurement range used. An exception is allowed for the idle mode. For this mode, the minimum accuracy is ±five percent of full-scale flow rate for the measurement range used. The controlling parameters are the elapsed time measurement of the event and the weight or volume measurement. You may apply the accuracy specifications of 40 CFR part 1065, subpart C, instead of those in this paragraph (b).

[70 FR 40449, July 13, 2005]

### § 90.418 Data evaluation for gaseous emissions.

For the evaluation of the gaseous emissions recording, record the last two minutes of each mode and determine the average values for HC, CO, CO<sub>2</sub> and NO<sub>x</sub> during each mode from the average concentration readings determined from the corresponding calibration data. Longer averaging times are acceptable, but the reported sampling period must be a continuous set of data.

[70 FR 40449, July 13, 2005]

### § 90.419 Raw emission sampling calculations—gasoline fueled engines.

(a) Derive the final weighted brake-specific mass emission rates (g/kW-hr) through the steps described in this section.

(b) *Air and fuel flow method.* If both air and fuel flow mass rates are measured, use the following equations to determine the weighted emission values for the test engine:

$$W_{NO_x} = (G_{AIRD} + G_{FUEL}) \times \frac{M_{NO_2}}{M_{exh}} \times WNO_x \times K_H \times \frac{1}{10^6}$$

$$W_{HC} = (G_{AIRD} + G_{FUEL}) \times \frac{M_{HC_{exh}}}{M_{exh}} \times WHC \times \frac{1}{10^6}$$

$$W_{CO} = (G_{AIRD} + G_{FUEL}) \times \frac{M_{CO}}{M_{exh}} \times WCO \times \frac{1}{10^2}$$

Where:

$W_{HC}$  = Mass rate of HC in exhaust [g/hr],

## Environmental Protection Agency

§ 90.419

$G_{\text{AIRD}}$  = Intake air mass flow rate on dry basis [g/hr],

$G_{\text{FUEL}}$  = Fuel mass flow rate [g/hr],

$M_{\text{HCexh}}$  = Molecular weight of hydrocarbons in the exhaust, see the following equation:

$$M_{\text{HCexh}} = 12.01 + \alpha 1.008 + \beta 16.00$$

Where:

$\alpha$  = Hydrogen/carbon atomic ratio of the fuel

$\beta$  = Oxygen/carbon atomic ratio of the fuel

$M_{\text{exh}}$  = Molecular weight of the total exhaust, see the following equation:

$$M_{\text{exh}} = \frac{M_{\text{HCexh}} \times \text{WHC}}{10^6} + \frac{28.01 \times \text{WCO}}{10^2} + \frac{44.01 \times \text{WCO}_2}{10^2} + \frac{46.01 \times \text{WNO}_x}{10^6} + \frac{32.00 \times \text{WO}_2}{10^2} + \frac{2.016 \times \text{WH}_2}{10^2} + 18.01 \times (1 - K) + \frac{28.01 \times \left[ 100 - \frac{\text{WHC}}{10^4} - \text{WCO} - \text{WCO}_2 - \frac{\text{WNO}_x}{10^4} - \text{WO}_2 - \text{WH}_2 - 100 \times (1 - K) \right]}{10^2}$$

Where:

WHC = HC volume concentration in exhaust, ppmC wet

WCO = CO percent concentration in the exhaust, wet

DCO = CO percent concentration in the exhaust, dry

WCO<sub>2</sub> = CO<sub>2</sub> percent concentration in the exhaust, wet

DCO<sub>2</sub> = CO<sub>2</sub> percent concentration in the exhaust, dry

WNO<sub>x</sub> = NO volume concentration in exhaust, ppm wet

WO<sub>2</sub> = O<sub>2</sub> percent concentration in the exhaust, wet

WH<sub>2</sub> = H<sub>2</sub> percent concentration in exhaust, wet

K = correction factor to be used when converting dry measurements to a wet basis. Therefore, wet concentration = dry concentration × K,

where K is:

$$K = \frac{1}{1 + 0.005 \times (\text{DCO} + \text{DCO}_2) \times \alpha - 0.01 \text{DH}_2}$$

DH<sub>2</sub> = H<sub>2</sub> percent concentration in exhaust, dry, calculated from the following equation:

$$\text{DH}_2 = \frac{0.5 \times \alpha \times \text{DCO} \times (\text{DCO} + \text{DCO}_2)}{\text{DCO} + (3 \times \text{DCO}_2)}$$

W<sub>co</sub> = Mass rate of CO in exhaust, [g/hr]

M<sub>co</sub> = Molecular weight of CO=28.01

W<sub>NOx</sub> = Mass rate of NO<sub>x</sub> in exhaust, [g/hr]

M<sub>NO2</sub> = Molecular weight of NO<sub>2</sub>=46.01

K<sub>H</sub> = Factor for correcting the effects of humidity on NO<sub>2</sub> formation for 4-stroke gasoline small engines, as follows:

$$K_H = (9.953 \times H + 0.832)$$

Where:

H = the amount of water in an ideal gas; 40 CFR 1065.645 describes how to determine this value (referred to as  $x_{\text{H}_2\text{O}}$ ).

K<sub>H</sub> = 1 for two-stroke gasoline engines.

(c) *Fuel flow method.* The following equations are to be used when fuel flow is selected as the basis for mass emission calculations using the raw gas method.

§ 90.419

40 CFR Ch. I (7–1–10 Edition)

$$W_{HC} = \frac{M_{HC_{exh}}}{M_F} \times \frac{G_{FUEL}}{TC} \times \frac{WHC}{10^4}$$

$$W_{CO} = \frac{M_{CO}}{M_F} \times \frac{G_{FUEL}}{TC} \times WCO$$

$$W_{NO_X} = \frac{M_{NO_X}}{M_F} \times \frac{G_{FUEL}}{TC} \times \frac{WNO_X}{10^4} \times K_H$$

Where:

$W_{HC}$  = Mass rate of HC in exhaust, [g/hr]

$M_{HC_{exh}}$  = Molecular weight of hydrocarbons in the exhaust, see following equation:

$$M_{HC_{exh}} = M_C + \alpha M_H + \beta M_O$$

$M_C$  = Molecular weight of carbon=12.01 [g/mole]

$M_H$  = Molecular weight of hydrogen=1.008 [g/mole]

$M_O$  = Molecular weight of oxygen=16.00 [g/mole]

$\alpha$  = Hydrogen to carbon ratio of the test fuel

$\beta$  = Oxygen to carbon ratio of the test fuel

$M_F$  = Molecular weight of test fuel

$G_{FUEL}$  = Fuel mass flow rate, [g/hr]

$TC$ =Total carbon in exhaust, see following equation:

$$TC = WCO + WCO_2 + \frac{WHC}{10^4}$$

$WCO$  = CO percent concentration in the exhaust, wet

$WCO_2$  = CO<sub>2</sub> percent concentration in the exhaust, wet

$DCO$  = CO percent concentration in the exhaust, dry

$DCO_2$  = CO<sub>2</sub> percent concentration in the exhaust, dry

$WHC$  = HC volume concentration in exhaust, ppmC wet

$WNO_X$  = NO<sub>x</sub> volume concentration in exhaust, ppm wet

$K$  = correction factor to be used when converting dry measurements to a wet basis. Therefore, wet concentration=dry concentration×K, where K is:

$$K = \frac{1}{1 + 0.005 \times (DCO + DCO_2) \times \alpha - 0.01 DH_2}$$

$DH_2$  = H<sub>2</sub> percent concentration in exhaust, dry, calculated from the following equation:

$$DH_2 = \frac{0.5 \times \alpha \times DCO \times (DCO + DCO_2)}{DCO + (3 \times DCO_2)}$$

$WCO$  = Mass rate of CO in exhaust, [g/hr]

$M_{CO}$  = Molecular weight of CO = 28.01

$WNO_X$  = Mass rate of NO<sub>x</sub> in exhaust, [g/hr]

$MNO_2$  = Molecular weight of NO<sub>2</sub>=46.01

$K_H$  = Factor for correcting the effects of humidity on NO<sub>2</sub> formation for 4-stroke gasoline small engines, as follows:

$$K_H = (9.953 \times H + 0.832)$$

Where:

$H$  = the amount of water in an ideal gas; 40 CFR 1065.645 describes how to determine this value (referred to as  $x_{H_2O}$ ).

$K_H$  = 1 for two-stroke gasoline engines.

(d) Calculate the final weighted brake-specific emission rate for each individual gas component using the following equation:

$$A_{WM} = \frac{\sum_i^n (W_i \times WF_i)}{\sum_i^n (P_i \times WF_i)}$$

Where:

$A_{WM}$  = Final weighted brake-specific mass emission rate (HC, CO, NO<sub>x</sub>) [g/kW-hr]

$W_i$  = Mass emission rate during mode i [g/hr]

$WF_i$  = Weighting factors for each mode according to § 90.410(a)

$P_i$  = Gross average power generated during mode i [kW], calculated from the following equation,

$$P_i = \frac{2\pi}{60,000} \times \text{speed} \times \text{torque}$$

Where:

speed = average engine speed measured during mode i [rev./minute]

torque = average engine torque measured during mode i [N-m]

[60 FR 34598, July 13, 1995, as amended at 70 FR 40449, July 13, 2005]